Reliability Assessment for WCTI Zero Blow Down (ZBD) Silica Based Technology

Introduction

This assessment will address the reliability afforded with the WCTI treatment process if an upset does occur with WCTI HES (high efficiency softening) pre-treatment systems, the effects that it might have on the system chemistry and the degree of forgiveness from potential scale formation during an upset.

As with any "results focused" water treatment program, steps should be in place to monitor and prevent conditions that would lead to equipment inefficiency. WCTI is first and foremost a water conservation program that uses economical pre-treatment and sustainable natural green chemistry to avert the need for tower blow down. As with any treatment approach, the approach requires a certain amount of involvement by both the customer and the WCTI licensed distributor.

Since this technology is a major paradigm shift in cooling water treatment concepts, questions on the technology and operation will naturally be generated by customers. Attempts will also be made by traditional water treatment companies or consultants to create concerns about the performance and risks with use of WCTI methods in their market place.

The discussions herein are provided to address such questions.

Q1: What happens if the HES is operated improperly, sending hard water to the tower?

A1: The first control response is to begin blow down to bring the level of hardness in the tower back within control range. The HES system malfunction must also be corrected to resume soft makeup. The response may also depend on whether the malfunction is a total loss of softening, only short term hardness from softener capacity over run, or low level hardness leakage. Response may also depend on the residual of increased hardness in the tower water relative to TDS concentration.

If other WCTI tower water control conditions (highly concentrated tower water TDS and alkalinity) have been maintained, there are several reasons why the highly concentrated and buffered tower water will prevent hardness scale formation prior to detecting and correcting the hardness upset.

First, highly cycled TDS will increase the solubility of hardness ions beyond their normal solubility and beyond the WCTI recommended maximum control limit of less than 30 mg/L total hardness in tower water. This increased solubility is the result of what is referred to in basic solubility chemistry as the non-common ion effect, and is particularly applicable in WCTI systems where highly soluble sodium ions from softening exchange is the predominant non-common metal ion that increases hardness solubility. It is well known that hardness residuals in seawater are many times greater than in surface waters due to high sodium and other dissolved ions that affect solubility of calcium and magnesium hardness. There are no precise models for this solubility effect due to variations in source water ions, but WCTI experience has found that cooling systems soluble hardness can typically be maintained at 1 mg/L of additional hardness above 30 mg/L for each 1000 TDS above 20,000 TDS. Thus a system operating at 50,000 TDS could be operated at 60 mg/L total soluble hardness without scaling potential.

Second, WCTI tower chemistry is comparable to low pressure boiler treatment chemistry, where high alkalinity residuals are maintained to prevent corrosion of steel, as well as to buffer the effects of potential hardness upsets. When hardness ions reach insoluble concentrations in the presence of excess alkalinity in boiler or tower water, calcium and magnesium hardness are immediately precipitated in the bulk water, much like in a lime and soda ash chemical softening process, rather than forming scale deposits on heat transfer surfaces. As with boiler water, the water may become cloudy from the precipitated hardness, but deposition is limited as long as excess alkalinity is present. Much greater concentrations of alkalinity, and this associated buffer effect, are maintained in WCTI treated systems than is possible in boilers since boilers tend to foam at high TDS and alkalinity levels. WCTI systems have operated at over 100 mg/L total hardness at pH 10 without precipitation where high TDS concentrations supported this increased solubility.

Third, an additional forgiveness factor is provided when soft water is restored to the tower system. In the very few cases when hardness upsets were not caught in time, when soft water was established again in the tower water, the soft water began gradually removing deposits from the system. Gradual removal of hardness deposits this way requires limited blow down to remove hardness dissolved from the tower system, while staying within the desired control range. WCTI chemistry has also proven it will remove hardness deposits left from prior chemical or NCD treated systems.

If a pre-treatment hardness upset or a hard water source of contamination to the tower is not corrected in time, scale deposition will eventually occur, as it would with conventional chemical treatment methods that have a loss of control of blow down, acid feed, or inhibitor feed. The buffer or "forgiveness" time factor depends on system volume, operating COC and heat exchange temperatures, but has proven to be equivalent or better than traditional chemical treatment approaches. The required frequency of hardness testing and monitoring must take these factors into consideration, along with the impact it may have on critical system equipment served by the cooling water. WCTI recommends daily operator hardness testing and logging for makeup and tower water samples. If such testing is not possible, automated remote monitoring systems may be considered (discussed below), depending on the potential impact to critical heat exchange equipment.

Q2: What happens with high temperature applications like autoclaves?

A2: WCTI chemistry has been found to work much better at higher bulk water and metal skin temperatures than traditional chemical treatments for both corrosion and scale control. For corrosion control, refer to high temperature corrosion studies by independent corrosion experts presented in papers at NACE. For scale control, a comparison to use of softened water in low pressure boiler treatment is relative to why WCTI treatment chemistry can operate without scaling at extreme high skin temperatures encountered in autoclaves.

<u>Low Pressure Boiler Deposit Control Chemistry (< 250 psi):</u>

Boiler deposits primarily result from low solubility hardness ions, and may end up on high temperature surfaces as scale if not properly controlled by pre-conditioning of the boiler feedwater by softening. Softening the boiler feedwater is crucial to manage boiler water chemistry. Boiler chemistry control steps are taken to insure that hardness and silica do not precipitate out on the surface of the tubes. The permissible concentration of silica in boiler water is based primarily on operating pressure. The majority of low pressure (<250 psi) boilers will have a silica limit of 150 mg/L as SiO_2.

Alkalinity is maintained in low pressure boilers, primarily from concentration of the carbonate alkalinity naturally present in the source water, or by addition of a chemical such as caustic (Na OH) when the source water does not have enough alkalinity. Higher alkalinity concentrations (pH > 10) increase the solubility of silica and avert formation of undesirable forms of silica that could form deposits. It also provides a buffer, as previously discussed, that will precipitate excess hardness in the boiler water during upsets rather than permitting hardness scale formation on heat transfer surfaces. Alkalinity also aids the protection of steel from corrosion by promotion of a stable iron oxide surface (magnetite).

<u>Traditional Chemical Treatment for Scale Control in Cooling Systems</u>

Tower makeup/*feedwater* for cooling systems normally does not go though any pre-treatment and consequently is susceptible to scaling conditions similar to boilers that use hard makeup water. Treatment chemicals are used to reduce the scaling potential, but are limited to only a very limited reduction in scaling tendencies, which is reflected in program control at low cycles of concentration (COC) to discharge hardness through blowdown water wastage. This scaling potential is much greater at high bulk water and high skin temperatures approaching 200^0F. Such high temperature applications may require use of acid feed to reduce alkalinity/pH in order to avoid hardness scale formation, but probably at the expense of corrosion protection for any steel or copper metals in the system (or the system requires use of expensive metal alloys to avoid corrosion failures).

WCTI Treatment for Scale Control in Cooling Systems

WCTI changes the rules by creating water conditions similar to pre-treated boiler feed water for cooling tower make-up water. This pre-treated water is facilitated by the removal of hardness ions *{calcium and magnesium*), followed by concentration of alkalinity, TDS and silica that remain in the water in the tower. High temperature heat transfer surfaces in an autoclave or any other exchange surface are protected from hardness scale by WCTI chemistry simply because of the absence of scaling ions, while the patented silica chemistry process eliminates silica deposition and corrosion of all system metals. If an upset in pre-treatment hardness removal should occur, the system is protected from scaling for the same reasons discussed previously in A1.

A good perspective would be that the maximum residual of soluble hardness being maintained by traditional chemical program design to conserve water provides a pre-established high quantity of hardness for deposition if there is a failure in blow down, inhibitor or pH control. The low soluble hardness residual maintained with the WCTI control range provides a significantly reduced quantity of potential hardness ions for deposit, and provides considerable forgiveness before concentrations will be reached that will cause scale. And you only have to control one variable, with a very simple hardness test, to avoid this consequence. That is why the WCTI program has experienced minimal occurrence of scale formation.

Relative to Autoclave cooling, extreme high skin temperatures may cause the water to flash off the heat transfer surface (as in a low pressure boiler), and if not rinsed by sufficient water flow, may form deposits from all minerals in the cooling water. When traditional chemical treated water, containing hardness *{calcium and magnesium},* is flashed on these high temperature Autoclave surfaces, they tend to form scale deposits that must be dissolved by acid to remove them from the surface. WCTI softened cooling water may also be subject to flash deposits, but will primarily be water soluble salts of sodium that can be dissolved and removed by soft water cleaning.

In one such application, test system design limited water flow and cooling of an engine block testing system to the point that film boiling and absence of water rinsing of the heat transfer surfaces lead to water salt deposits with any treatment approach. However, with WCTI soft water chemistry, the deposits (sodium salts) could be rinsed off without use of acid treatment to remove $CaCO^3$ scale formed with traditional hard water and chemical treatment approaches.

Q3: Is there any way to monitor the WCTI program remotely?

A3: Traditional chemical treatment programs require customer and distributor service efforts to maintain and control chemical inventory, bleed solenoids, chemical pumps, and other test and control systems. In the case of the WCTI program, the HES (High Efficiency Softener) system is the primary and only control that has to be monitored and maintained.

WCTI encourages customer operator involvement and accountability for HES reliability through simple, reliable and routine operator hardness testing (and logging), rather than reliance on remote monitoring systems. However, for some critical or limited staff operations, remote monitoring is desirable. Monitoring systems can be unreliable if not routinely compared and calibrated by manual test results. Either the customer or the distributor service commitment should insure such routine comparisons are made at a frequency based on potential system impact and reliability risk. With correct support and verification, remote monitoring will improve overall system reliability.

Monitoring Tools

The WCTI process does not need to rely on remote monitoring tools and is manageable and economical with simple manual testing. However, there are facilities where it is desirable to increase reliability, such as an N+1 environment and remote / minimal staffed facilities. Remote monitoring test and control tools that can increase reliability are recommended below.

- ❖ Hardness monitoring
- ❖ RPA (Regeneration Performance Analysis, aka, Elution Study) monitoring

<u>Hardness Monitoring</u>

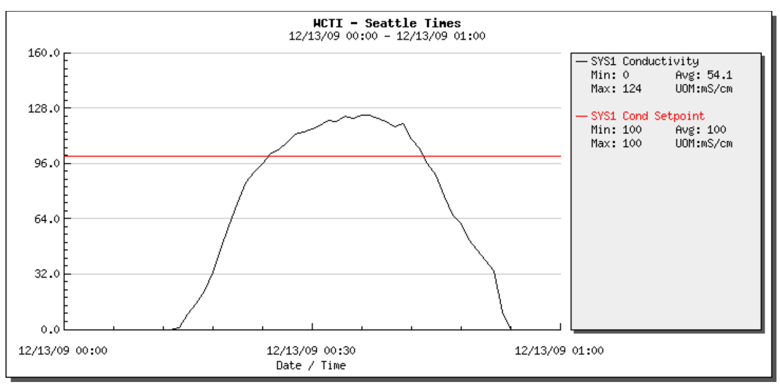
Although this remote monitoring method is well established, it is not the best choice from WCTI's perspective. Reliability and maintenance challenges, as well as cost of reagents may be undesirable to the customer. This traditional monitoring tool should only be used when operator testing is not feasible, as it will significantly increase cost of operation for the customer. Hardness monitors do not diagnose the source of softener problems, and can give false alarms during the normal transition of softener service vessels. They are also not applicable for monitoring cooling tower water hardness when operating at zero blowdown due to the effect of high TDS and pH that interfere with sensor color detection. There are a number of hardness monitors available on the market.

The Hach APA 6000 Low Range Hardness Analyzer provides real time low level hardness monitoring that gives you a 30 day supply of reagents. This unit has the ability to alarm in real time and has internet of local LAN monitoring availability.

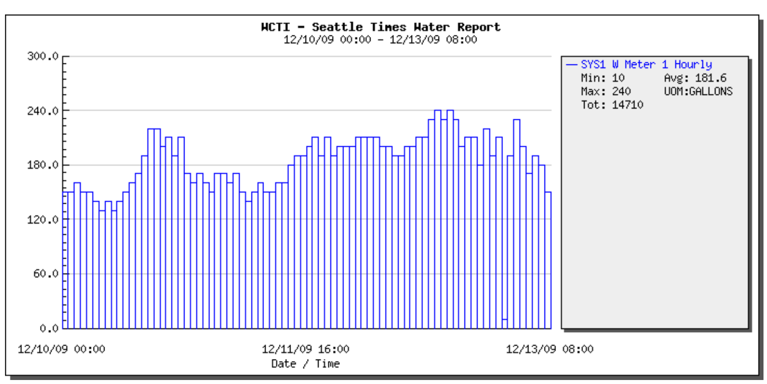
This can provide operations an additional tool to assure good hardness is continually entering the system. There are other less expensive units available that do not give you real time on line monitoring and require less frequent reagent replacement.

RPA (Regeneration Performance Analysis, aka, on line Elution Studies)

Automated RPA reporting with Ethernet, phone line or wireless data card options with the controller



On line monitoring of each HES regeneration, with failure alarm



On line makeup water flow monitoring and meter control verification

This Technology is patented by the Water Conservation Technology International, Inc.

U.S. Patents 6,929,749; 6,949,193; 6,998,092; 7,122,148 (V012210)

RPA System Description

The RPA system provides a proven reliable and low maintenance testing method for online monitoring of the regeneration process of WCTI High Efficiency Softener (HES) equipment. The RPA system uses state of the art online communication and software that monitors conductivity throughout the regeneration, and will send an alarm to service staff in the event of a failure that will lead to short service runs and hardness leakage. The RPA system eliminates hours of time required to perform just one traditional elution study, and permits analysis of every regeneration to insure reliability and enable performance optimization. RPA includes on-line monitoring of the critical HES reliability functions 1) regeneration brine strength, 2) metered flow, and 3) control power loss. For further details, download the RPA bulletin at http://www.water-cti.com on the Technical Reports page.

Reliability Assessment Summary

Application of traditional chemical treatments does reduce scale and corrosion potential, but does not eliminate operational reliability risks that occur with failure of their control systems. Use of remote monitoring for traditional chemical programs or WCTI systems can improve reliability, if they do not replace customer and service distributor verification of control.

WCTI water treatment methods are a paradigm shift in core capabilities for the water treatment industry that eliminates reliance on traditional chemical water treatment concepts and limitations. Many years of testing and field operation have established that the performance and reliability of this technology is exceptionally viable, even though it does not conform to traditional chemical treatment assessment methods or “indexes”. Customers must consider that concerns that originate from the traditional chemical treatment industry are often based on the threat is poses to minimize chemical use and their industry presence. We have seen numerous attempts by chemical companies to create customer concerns with erroneous remarks that clearly indicate that they do not understand this new chemistry or choose to misinform.